5. Maintenance of healthy ecosystems.

6. Reduced probability of insect outbreaks.

7. Reduction of tree diseases.

6.15 - Stand Selection Criteria. Selecting a stand for thinning is dependent upon the silvicultural characteristics and priorities identified in Forest Land Management Plans. Special recommendations for setting priorities are included in exhibit 01. Consider the following items in selecting stands:

1. Age. Age refers to both the chronological age and the length of time in a competitive status. Ideally, stands should be thinned at a young age, with the chronological ages ranging from 15 to 30 years. The range in age is principally dependent on the species, site capability, and other factors which contribute to the trees ability to compete for the most limiting environmental factors. Thinning should generally be delayed until trees are expressing their mature growth and quality characteristics and are capable of deterring brush and other site competition by adequate occupancy of the site.

The longer thinning is delayed after competition among trees begins, the greater is the unrealized usable production. Tree growth begins to be reduced by competition well before the competition becomes readily apparent. For instance, in Douglas-fir, by the time lower branches start dying, competition is already quite advanced.

It will be necessary to compare the actual stocking rate to the density necessary to achieve a commercial size objective. This comparison may be necessary when there is a small number of trees per acre, but the first commercially marketable product is relatively large in size. For example; a ponderosa pine stand which is growing on a Douglas-fir/ninebark habitat type has a stocking rate of 220 3-inch trees per acre. That stocking should result in the production of 9-inch to 10-inch trees before moisture competition occurs. That stocking rate would result in severe competition and mortality occurring over a long period of time if markets changed and a 14-inch to 15-inch diameter tree was necessary for a first marketable product.

If initial stocking two to three years after disturbance is excessive (10-40 thousand trees per acre) weeding and cleaning may be needed by age 4-5 if high precommercial thinning costs are to be avoided.

2. Crown Ratio or Crown Percent. The crown area development is often an expression of the competitive stature of a tree within a stand. Tolerant species are more capable of maintaining large crowns even in low-light levels if all other factors are not limiting. Intolerant species lose lower needles more rapidly from competition for light, with all other factors not limiting. Trees, however, naturally tend to lose crown area with increasing age.

Within each species, there is an inherent capability for production of photosynthetic surface area. This surface, primarily the needle area in conifers, will remain relatively constant on a site resulting in diminished overall crown lengths in denser stands. The crown area length in relation to the total tree height is expressed as a ratio or percent. For example; a tree 50 feet in total height with a live crown length of 30 feet has 60 percent crown ratio. For the best thinning response, crown ratios should be greater than 40 percent of the total bole length, preferably greater than 1/2 the length. In some stands with a high density and young age (5-20 years old), thinning when crown ratios are 25-35 percent may be appropriate.

Tolerance is expressed below for the most common species in the Regions. The most tolerant species utilize the photosynthates at lower light levels and higher levels of root competition than more intolerant species. Most species become less tolerant with age.

Very Tolerant	Tolerant	Intermediate	Intolerant	Very Intolerant
Pacific Yew	Engelmann spruce	Blue spruce	Apache pine	Alpine larch
Subalpine fir	Grand fir	Douglas-fir	Chihuahua pine	Bristlecone pine
Western Red Cedar	Incense-cedar	Sugar pine	Jeffery pine	Cottonwoods
Western Hemlock	Mountain hemlock	Western white pine	Junipers	Quaking aspen
	Red fir		Limber pine	Subalpine larch
	White fir		Lodgepole pine	Western larch
	White spruce		Pinyon pine	Whitebark pine
			Ponderosa pine	
			Southwestern white pine	

3. Stand Density. The benefits of thinning increase as initial density or number of stems per acre increase. Overstocking results in stands either not reaching merchantable sizes or reaching them very slowly, especially on lower productivity lands (site classes V, VI, and VII) (Exhibit 01). High productivity lands will nearly always produce merchantable volume without major reductions in density. First priority for precommercial thinning should be given to young stands on lower productive sites that are overdense. These stands are those which would seldom produce merchantable volume without thinning. It is because little value comes from the stands without thinning that nearly all the volume gain; hence, economic value is attributable to the precommercial thinning. If stand density is so high that conventional thinning methods are economically unfeasible consideration should be give to stand replacement. The methods for stand replacement should consider the use of prescribed fire.

A primary gain from precommercial thinning is a shortening of the time a stand must be carried before it is commercially thinned. Generally, the longer the time required for trees to reach commercial size without thinning, the greater the gain from precommercial thinning. This is accomplished by placing the growth on the trees which will reach commercial size and eventually producing the final crop trees.

More usable biomass is captured by completing precommercial thinnings on the young, less dense stands than on the older larger stands. When density is combined with the relative age of the stand, it becomes readily apparent that older overdense stands create a larger volume of slash than a younger less dense stand.

6.15 - Exhibit 01

Stand Selection Criteria

Site Productivity Class Table

Potential Productivity Cubic Feet/Acre/Year	Site Class
0-19	VII
20-49	VI
50-84	V
85-119	IV
120-164	III
165-224	II
225-500	I

4. Height - Diameter. Both height and diameter provide a relative expression of the chronological age of a stand. Many species have varying height growth patterns that can be determined in yield tables, site index, and height growth curves. In many cases, these curves will allow the prediction of the potential height and diameter within a specific time frame. Thus, in young stands, the point of culmination of annual height growth can be determined. Gains from thinning decline very rapidly after this point of culmination.

Percentage gains in mean annual increment (m.a.i.) of usable volume due to precommercial thinnings are closely related to site quality. Percentage gains from precommercial thinning, within limits, increase markedly with decreasing site quality. The resulting absolute gains in usable mean annual increment also increases with decreasing site quality to site class V.

If precommercial thinning is not done until leave trees are about 30 feet or 20 percent of its rotation height, the opportunity to make potential gains in growth response may no longer be possible. Leave trees should also be within plus or minus 25 percent of the average diameter for all leave trees within that portion of the treated stand. Excessively dominant large diameter of "wolf-trees" should not be left as part of the leave stand. These trees, excessive dominants, poorly utilize the site, often having extremely long limbs of large size which occupy two to three times the crown area of normal dominant or co-dominant trees. Where other resource consideration dominate the management practices or objectives in a stand, retention of the wolf trees may be necessary or desirable.

Lodgepole pine stands often require that no thinning be accomplished until they are at least 15 feet in height unless the density is so great that trees begin self pruning. Any other precocious seed producers should be similarly treated. A re-invasion or release of undergrowth shrubs, brush, or small trees can also be severe competition, especially when moisture is the most limiting factor for growth. This is to reduce competition due to re-establishment of seedlings. Super dense stands left unthinned will lose their growth (diameter and height) potential to respond to thinning.

Diameter of material being thinned is a very important consideration in determining the volume and type of fuel hazard created. Excessive amounts of slash and the relatively short period of time until the tree reaches commercial size should limit thinning to stands with average stand diameter less than 5 inches d.b.h. The most desirable stands to thin would be those of less than 3 inches in average stand diameter, before thinning.

5. Site Quality. Site quality is the sum of all the environmental factors that determine the productivity of a forest land area. Indirect methods of measuring these environmental factors are site index and vegetation classification systems. The most typical vegetation classification system is the habitat type.

Site index, when properly obtained from dominant trees, is an expression of site productivity especially the height attainable. Over-dense stands, especially intolerant species, will not grow to their full height. Therefore, the site's true potential would not be indicated.

When over-dense stands or young stands exist on the site, the vegetational classification system of Daubenmire's habitat types will provide a rapid approximation of the site's productive capability.

While the common approach has been to invest production dollars on the highest quality sites, percentage gains from precommercial thinnings increase markedly with decreasing site quality through site classes IV and V. This results because the gain in usable mean annual increment attributable for the thinning increases with decreasing site quality. Poorer quality sites have a number of limiting silvicultural or environmental factors. When these factors are not affected, through reductions in densities, the resultant stand cannot produce commercial products except over long time periods, occasionally not at all. High site quality stands nearly always produce commercial products, even with high densities.

6. Vigor. This factor is a relative expression normally associated with trees in the main or dominant story of the stand. Attributes normally used to describe vigor are terminal elongation and needle color, size, and length. Tree vigor often aids in the evaluation of the leave stands ability to dominate the site through response to a decrease in any of the limiting factors.

The rate of leader growth or the distance between internodes provides an excellent measure to the release potential of the site. Elongation of the crown area provides the greatest carbohydrate production potential for height and diameter growth.

The position of a tree's crown in relation to trees adjacent to it provides the best overall assessment of a tree's capability to respond to reductions in density. Kraft's even-aged crown classification system portrays the crown of a tree in relation to the exposure to sunlight and relative height within the stand. The classifications are:

a. Dominant Trees. Dominant trees are somewhat above the general level of the canopy and are exposed to full sunlight from above and to a certain extent laterally.

"Wolf Trees" are coarse, heavy-limbed, broad-crowned trees that have usually developed with a lack of lateral, co-dominant competition. Wolf trees are undesirable in a stand from a timber management standpoint. These trees may be desirable for other resource considerations.

b. Co-Dominant-Trees. Co-dominant trees are not as tall as dominants, with crowns receiving overhead light. They may be confined laterally by dominants and usually make up the main canopy with the dominants.

c. Intermediate Trees. Intermediate trees are definitely subordinate in position receiving direct sunlight only through holes in the canopy. All trees of this class are subject to strong lateral competition.

d. Suppressed Trees. Suppressed trees are definitely overtopped with no free overhead light. Commonly weak and slow growing.

e. Dead Trees. Self-explanatory.

Stand leave trees should normally be selected from dominant and co-dominant crown classes especially in precommercial stand sizes. When necessary, intermediate crown classes may be left to maintain crown coverage and site occupancy if no others are available or if a specific species is desired to meet other resource concerns. Suppressed trees will seldom respond to thinning and should not be selected as leave trees.

Tolerant species (6.15, item 2), when overtopped or overdense, may have thin bark and a well developed "shade leaf" crown. Sudden exposure of trees in these stands to light through removal of an overstory and thinning can result in "sunburning" or "sunscald" of the bole and loss of needles. This normally causes diminished growth and delayed site occupancy or death. Occasionally, mortality may be high in these stands if other stressful environmental conditions, such as aspect, coincide with the induced stress of treatment. "Sunburning" is necrosis caused by excessive heating of the cambial tissue under the thin bark, which often results in flattened sides, bark sluffing, and poor wood quality.

Grand fir stands more than 30 years of age that have been suppressed and released through logging should not be thinned until 2 to 5 years after release. This will allow an assessment of release ability to occur. Grand fir will not respond to thinning when crown ratios are below 40 percent.

7. <u>Stand Damage</u>. This single element often holds the key to the final selection of a stand for thinning. All potential insect and disease hazards in the stand proposed for thinning must be evaluated or rated.

Thinning is often an effective method of reducing current losses from insects and disease in young stands. It is also an effective method of controlling insects in the future. The general vigor of the stand will be improved by thinning, and the ability to overcome insects, such as the western and mountain pine beetle, will be increased. Changes of environment within the stand, especially the increase in temperatures within the stand, appears to be detrimental to a number of insects.

Thinning under an overstory infected with dwarf mistletoe should not be done. Early removal of the affected overstory, preferably by commercial sales, will benefit the stand. When thinning in stands infected with dwarf mistletoe, it will be necessary to preprogram several follow-up inspections and possibly some additional treatments to deal with latent infections that becomes visible 3 to 5 years after the initial treatment. Hawksworth's 6-class dwarf mistletoe rating system (ex. 02) should be used in programming treatments for dwarf mistletoe infected stands.

6.15 - Exhibit 02

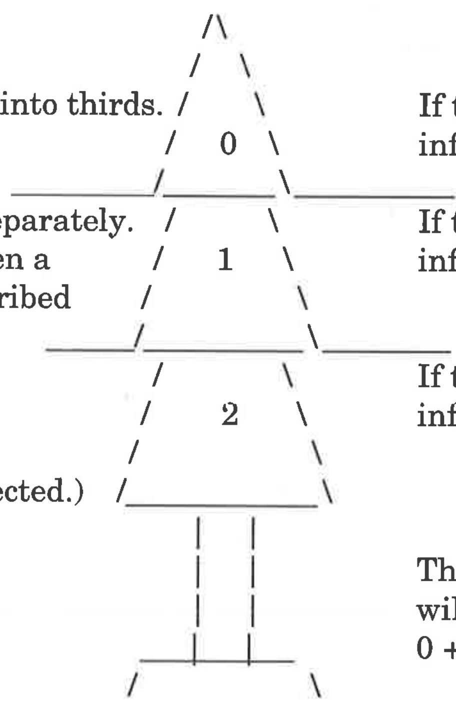
Hawksworth 6-Class Mistletoe Rating System

INSTRUCTIONS

STEP 1. Divide live crown into thirds.

STEP 2. Rate each third separately. Each third should be given a rating of 0, 1 or 2 as described below.
(0) No visible infections.
(1) Light infection (1/2 or less of total number of branches in the third infected.)
(2) Heavy infection (more than 1/2 of total number of branches in the third infected.)

STEP 3. Finally, add ratings of thirds to obtain rating for total tree.



EXAMPLE

If this third has no visible infections, its rating is (0)

If this third is lightly infected, its rating is (1)

If this third is heavily infected, its rating is (2)

The tree in this example will receive a rating of 0 + 1 + 2 = 3.

The 6-class mistletoe rating system (Hawksworth 1961).

The level of infection and site productivity must be considered when prioritizing stands with dwarf mistletoe infections. Better site indices should be given a higher priority because of greater potential volume growth. As the mistletoe ratings increase, the priority for thinning should decrease. Stands with a rating class of 2 or less with infections in the lower crown will benefit from thinning and may produce acceptable yields.

Rust and gall infected stands can be substantially improved by careful selection of leave trees. Commonly, some trees within the stand have a genetic resistance to these pathogens. The apparent rate of resistance and lack of galls should be considered in prioritizing these stands for treatment.

The species susceptibility to current insect or disease problems should be evaluated. Many mixed stands contain nonhost species which could be featured in management to help eliminate or control the pathogen or insect.

The development of infection entry points must be considered when prioritizing stands for treatment. Commercial thinnings or removal of salvage materials must consider the scarring, limb breakage, season of the year, and other circumstances creating rust or fungal entry points. True firs are very susceptible to various rots. Treatment types which increase this susceptibility must be given a low priority.

Timing of thinning operations is essential in many stands. Insect populations such as ips can build up rapidly in slash. By creating a "green chain" of slash, this problem may be avoided. This often means attracting the insects into down materials until winter when freezing and drying kills the overwintering larval stage. There are situations in Arizona and New Mexico when the "green chain" is not effective because winters are not severe enough to kill ips broods. In these situations control is provided by limiting the amount of slash (brood material) in any one location. Specific insects or disease treatments should be discussed with an entomologist or pathologist.

8. Management Objectives. The items above are the principal silvicultural considerations that should be weighed in stand selection for thinning. Silviculture properly applied requires that the stand capabilities be utilized to meet management objectives. The following objectives further set priorities on stands selected for thinning and other treatments.

a. Species Composition. The species selected may have considerable influence on insect and disease susceptibility, potential production, economic demand, and legal or administrative constraints.

Stands of higher valued species will normally show a greater return for the investment of thinning funds than low value species (all other considerations being equal). While current price or demand must have a greater weight than future price/demand considerations, the future should be weighed when considering relative priorities between species. Continued increases in demand for fiber in the form of chips will not only change the type of output from the various stands, but could change the price/market structure changing demands from species having high quality sawtimber to a dual production species having moderately good wood structure and fiber quality. This demand picture must be reviewed with the emphasis on the local demand or market area.

Ability to alter output rates and types must be evaluated in relation to the overall stand management objective. The ability to produce a mixture of species is often desired to maintain vigor over time and reduce susceptibility to damaging agents. Biologically, many species may be produced on one habitat type, but a seral species may be more productive than the climax species. Species composition often needs to be controlled for management purposes. Caution needs to be exercised, however, in some species because basic biological reactions tend to exclude certain species because of competitive interactions.

Diversity of the wildlife species inhabiting a stand is directly affected by its composition. Wildlife habitat objectives may require a broad array of species to meet stand management objectives.

b. Plans. Management plans, objectives, and constraints often impose thinning priorities such as spacing, area of treatment, or timing. These constraints should be considered when setting priorities for expenditures. The objectives and constraints will normally be found in the silvicultural prescription for the stand or area.

Management plans also place priorities on areas of treatment to meet planned harvest objectives. These planned harvest objectives may have included economical efficiency in their initial determination of need and, as such, may have programed certain management types to be treated over a specific time period.

Some stands are predesignated for thinning by Forest plans rather than silvical priorities. They are set aside to meet future timber management output objectives or other resource objectives. These targeted areas are first priority in a management schedule.

9. Disturbance Regimes (Fire). In addition to stand level silvicultural characteristics and identified land management objectives, stand selection criteria should consider concepts of disturbance ecology from a stand and landscape perspective. Understanding of past, current, and potential future fire regimes for example, can give us clues to sustainable desired conditions in terms of composition and structure of stands and landscapes. An understanding of historical fire regimes can give us a clue to the frequency and intensity of fire, the type of stand and landscape structures that were developed, and possible wildlife habitat that was maintained over time. This knowledge can then be used to help define desired stand and landscape conditions to be developed over time as we prepare site specific silvicultural prescriptions. Understanding how and where fire regimes influenced past composition and structure should aid in setting priorities for current TSI treatments.

10. Economics. Similar stands are often in need of thinning. An analysis should be conducted to rank stands so that the greatest return is realized for each dollar invested. Analysis of these treatments should be included in Land Management Plans, Environmental Assessments/Impact Statements, and/or final silvicultural prescriptions. The most current applicable technique for conducting an economic analysis is to be used.

After analysis is completed, implementors of these stand treatment activities will need to evaluate and select the most cost efficient means for completing the activities. Consideration will include: available funding; contract versus force account; administration costs; move in and out costs; season of work; coordination with resource values and uses; and methods to be used.

11. Review of the Stand Selection Process. The following is a description of an approach to developing priorities for thinning using the stand selection criteria developed above. While the stand selection criteria basically is divided into two segments, not all segments must be considered in making the stand selection. The priorities are provided as a logic pattern to help order a complex program of scheduling. The questions that are outlined below, when answered, should provide a ranking of stands for thinning.

a. Age. Has competition between trees developed? Have the trees in the stand begun to express growth and quality characteristics (Phenotypic)? Are the trees old or excessively stagnant?

b. Crown Ratio. Is there sufficient crown present to immediately respond to density reduction? Must the foliage go through adjustment? Can more crown be added?

c. Density. Can the stand reach commercial size without significantly extending the time needed to achieve the projected size at the end of a typical rotation? What will be the volume of fuel created in unutilized wood fiber? Is the stand too dense and of such poor quality as to not achieve an expression of dominance?

d. Height-Diameter. Is the variation in diameter in the leave trees greater than plus or minus 25 percent? Has the stand differentiated in height? Are trees past the point of culmination of mean annual and periodic increment?

e. Site Class. Does the habitat type capability indicate that stagnation is common for the density present?

f. Vigor. Is the dominance freely expressed with extreme variations present in the upper 1/3 of the crown in internode elongation? Will the trees continue to grow at a rate that will capture the site and control competing vegetation?

g. Stand Damage. What insects and diseases are present? What are the future problems with insects and diseases that could be triggered by treatment of the stand?

h. Species Composition. What species will provide the best future returns? Is there a need to favor a certain species or species mixes for insect and disease purposes?

i. Plans. Is the area included as a priority treatment within the Forest Land Management Plan? Is stand density or composition controlled by some other resource constraint? Must scheduling be delayed or the intensity for treatment reduced?

j. Disturbance Regimes (Fire). Is the stand composition and structure close to the historic range given the typical historical fire regime on the site? If not, is this stand condition likely to lead to a sustainable stand and landscape condition in terms of the current or projected future fire regime? Is the stand so large as to create problems with fire, other resources, or future forest management activities?

k. Economics. Which of the selected stands to be treated will provide the best benefit-cost ratio or has the best present net worth?

This list of questions is incomplete and is only provided to stimulate the analysis procedure used in stand selection.

6.16 - Project Development.

1. Area Layout. Area layout consists of four basic steps: (1) check the approved Environmental Analysis or assessment and silvicultural examination to ascertain the general boundaries of the area and to ensure specific coordination measures are incorporated into the project; (2) locate and mark boundaries of the specific units to be thinned; (3) develop a project map to scale; and (4) determine the acreage of each unit.

The first step is to ensure that the Forest Land Management Plan and the parent or specific project environmental analysis or assessment are being followed. It is also important to ensure the area and timing of your project do not conflict with other resource and timber projects. Boundary layout should begin next. Maps, aerial photos with the boundaries of each prescription unit to be thinned plainly delineated, and flagging should be taken along and used to layout the area on ground. If transmission lines, roads, or trails are used as boundaries, make sure that they are correct on your maps and photos. These features sometimes change between the time the maps were made or aerial photos were taken. Care should be used in the layout phase to ensure that units are not too large for the available work forces.

Whenever possible, it is best to use topographical or other easily identifiable landmarks as boundaries as this will help in determination of unit acreage.